Applicant: Rodenstock GmbH
Series of Progressive Ophthalmic Lenses with Low Divergence and Rotation of Astigmatism
Our ref.: R 1919 - ro/hf

**Patent Claims**

1. Method for producing a progressive ophthalmic lenses having at least one progressive surface, whereby the lens comprises

- a far vision part designed for seeing at great distances and having a far reference point,
- a near vision part designed for seeing at short distances and having a near reference point,
- a progression zone situated between the far vision part and the near vision part, where the effect of the lens increases by a value known as addition along a principal line from the value at the far reference point to the value at the near reference point,

whereby a calculation and optimization step [in the production] of the progressive lens is performed so that the absolute value of the rotation $|\mathrm{rot}\vec{A}|$ and/or the divergence $|\mathrm{div}\vec{A}|$ of a vectorial astigmatism $\vec{A}$ is as small as possible, whereby the absolute value $|\vec{A}|$ of the vectorial astigmatism $\vec{A}$ is proportional to the absolute value of an astigmatism in the use position of the progressive lens or a surface astigmatism of the at least one progressive surface of the progressive lens, and the direction of the vectorial astigmatism $\vec{A}$ is proportional to the cylinder axis of an astigmatism in the use position of the progressive lens or a surface astigmatism of the at least one progressive surface of the progressive lens.

2. Method as claimed in Claim 1, whereby the calculation and optimization step is performed so that global maximum of the absolute value $|\mathrm{div}\vec{A}|$ of the divergence of the vectorial astigmatism $\vec{A}$ is outside the zone of good visual acuity of the lens in which the absolute value of the vectorial

astigmatism $|\vec{A}|$ is less than 0.6 dpt and is preferably located in the peripheral area of the lens.

3. Method as claimed in any one of the preceding claims, whereby the calculation and optimization step is performed so that the x coordinate of the position of the global maximum of the absolute value $|\mathrm{div}\vec{A}|$ of the divergence of the vectorial astigmatism $\vec{A}$ is greater than 6.0 mm and the y coordinate is less than -8.5 mm, and whereby x is the horizontal axis and y is the vertical axis in the use position and the zero point x = 0, y = 0 is 4 mm below the centering point of the lens.

4. Method as claimed in any one of the preceding claims, whereby the calculation and optimization step is performed so that all extremes of the absolute value $|\mathrm{div}\vec{A}|$ of the divergence of the vectorial astigmatism $\vec{A}$ which exceed the value of (0.1/mm) times the addition for all progressive surfaces having addition ≥2.0 dpt are outside of the range y ≥ -9 mm of the lens.

5. Method as claimed in any one of the preceding claims, whereby the calculation and optimization step is performed so that the absolute value $|\mathrm{rot}\vec{A}|$ of the rotation of the vectorial astigmatism $\vec{A}$ in the near vision part and/or in the far vision part does not exceed a maximum value of $|\mathrm{rot}\vec{A}|_{max} \approx 0.25$ addition/dpt·dpt/mm.

6. Method as claimed in any one of the preceding claims, whereby the calculation and optimization step is performed so that the absolute value $|\mathrm{rot}\vec{A}|$ of the rotation of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = -14 mm does not exceed a maximum value of $|\mathrm{rot}\vec{A}|_{max} \approx 0.115$ addition/dpt·dpt/mm, preferably $|\mathrm{rot}\vec{A}|_{max} \approx 0.08$ addition/dpt·dpt/mm.

7. Method as claimed in any one of the preceding claims, whereby the calculation and optimization step is performed so that the absolute value $|\mathrm{rot}\vec{A}|$ of the rotation of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = +6 mm does not exceed a maximum value of $|\mathrm{rot}\vec{A}|_{max} \approx 0.115$ addition/dpt·dpt/mm, preferably $|\mathrm{rot}\vec{A}|_{max} \approx 0.06$ addition/dpt·dpt/mm.

8. Method as claimed in any one of the preceding claims, whereby the calculation and optimization step is performed so that in the far vision part between y = 3 mm and y = 5 mm there is a horizontal section y = const along which the absolute value $|\mathrm{rot}\vec{A}|$ of the rotation of the vectorial astigmatism $\vec{A}$ increases monotonically from the principal line outward to a coordinate of $|x|$ = 16 mm.

9. Method as claimed in any one of the preceding claims, whereby the calculation and optimization step is performed so that the divergence $\mathrm{div}\vec{A}$ of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = 0 mm does not exceed a maximum value of $(\mathrm{div}\vec{A})_{max} \approx$ (0.11 addition/dpt + 0.03) dpt/mm, preferably $(\mathrm{div}\vec{A})_{max} \approx$ (0.08 addition/dpt + 0.03) dpt/mm.

10. Method as claimed in any one of the preceding claims, whereby the calculation and optimization step is performed so that the divergence $\mathrm{div}\vec{A}$ of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = 0 mm does not drop below a minimum value of $(\mathrm{div}\vec{A})_{min} \approx$ (-0.07 addition/dpt - 0.11) dpt/mm, preferably $(\mathrm{div}\vec{A})_{min} \approx$ (-0.05 addition/dpt - 0.08) dpt/mm.

11. Method as claimed in any one of the preceding claims, whereby the calculation and optimization step is performed so that the divergence $\mathrm{div}\vec{A}$ of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = -14 mm does not exceed a maximum value of $(\mathrm{div}\vec{A})_{max} \approx$ (0.12 addition/dpt + 0.06) dpt/mm.

12. Method as claimed in any one of the preceding claims, whereby the calculation and optimization step is performed so that the divergence $\mathrm{div}\vec{A}$ of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = -14 mm does not drop below a minimum value of $(\mathrm{div}\vec{A})_{min} \approx$ (-0.13 addition/dpt - 0.05) dpt/mm.

13. Progressive ophthalmic lens having at least one progressive surface, whereby the lens comprises at least:
   - a far vision part designed for seeing at great distances and having a far reference point,
   - a near vision part designed for seeing at short distances and having a near reference point,
   - a progression zone situated between the far vision part and the near vision part where the effect of the lens increases from a value known as addition along a principal line from the value at the far reference point to the value at the near reference point,

whereby
   - the global maximum of the absolute value $|\mathrm{div}\vec{A}|$ of the divergence of a vectorial astigmatism $\vec{A}$ is outside the zone of good visual acuity of the lens in which the absolute value of vectorial astigmatism $|\vec{A}|$ is less than 0.6 dpt and is preferably located in the peripheral area of the lens and/or
   - the absolute value $|\mathrm{rot}\vec{A}|$ of the rotation of the vectorial astigmatism $\vec{A}$ in the near vision part and/or in the far vision part does not exceed a maximum value of $|\mathrm{rot}\vec{A}|_{max} \approx$ 0.25 addition/dpt·dpt/mm, and

whereby the absolute value $|\vec{A}|$ of the vectorial astigmatism $\vec{A}$ is proportional to the absolute value of an astigmatism in the use position of the progressive lens or a surface astigmatism of the at least one progressive surface of the progressive lens, and the direction of the vectorial astigmatism $\vec{A}$ is proportional to the cylinder axis of an astigmatism in the use position of the progressive lens or a surface astigmatism of the at least one progressive surface of the progressive lens.

14. Progressive lens as claimed in Claim 13, whereby the x coordinate of the position of the global maximum of the absolute $\vec{A}$ value $|\mathrm{div}\vec{A}|$ of the divergence of the vectorial astigmatism $\vec{A}$ is greater than 6.0 mm and the y coordinate is less than -8.5 mm and whereby x is the horizontal axis and y is the vertical axis in the use position, and the zero point x = 0, y = 0 is located 4 millimeter below the centering point of the lens.

15. Progressive lens as claimed in any one of Claims 13 or 14, whereby for all progressive surfaces with addition ≥2.0 dpt, all extremes of the absolute value $|\mathrm{div}\vec{A}|$ of the divergence of the vectorial astigmatism $\vec{A}$ exceeding the value of (0.1/mm) times the addition are outside of the range $y \geq -9$ mm of the lens.

16. Progressive lens as claimed in any one of Claims 13 through 15, whereby the absolute value $|\mathrm{rot}\vec{A}|$ of the rotation of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = -14 mm does not exceed a maximum value of $|\mathrm{rot}\vec{A}|_{max} \approx$ 0.115 addition/dpt·dpt/mm, preferably $|\mathrm{rot}\vec{A}|_{max} \approx$ 0.08 addition/dpt·dpt/mm.

17. Progressive lens as claimed in any one of Claims 13 through 16, whereby the absolute value $|\mathrm{rot}\vec{A}|$ of the rotation of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = +6 mm does not exceed a maximum value of $|\mathrm{rot}\vec{A}|_{max} \approx$ 0.115 addition/dpt·dpt/mm, preferably $|\mathrm{rot}\vec{A}|_{max} \approx$ 0.06 addition/dpt·dpt/mm.

18. Progressive lens as claimed in any one of Claims 13 through 17, whereby in the far vision part between y = 3 mm and y = 5 mm there is a horizontal section y = const along which the absolute value $|\mathrm{rot}\vec{A}|$ of the rotation of the vectorial astigmatism $\vec{A}$ increases monotonically from the principal line outward to a coordinate of $|x|$ = 16 mm.

19. Progressive lens as claimed in any one of Claims 13 through 18, whereby the divergence $\mathrm{div}\vec{A}$ of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = 0 mm does not exceed a maximum value of $(\mathrm{div}\vec{A})_{max} \approx$ (0.11 addition/dpt + 0.03) dpt/mm, preferably $(\mathrm{div}\vec{A})_{max} \approx$ (0.08 addition/dpt + 0.03) dpt/mm.

20. Progressive lens as claimed in any one of Claims 13 through 19, whereby the divergence $\mathrm{div}\vec{A}$ of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = 0 mm does not drop below a minimum value of $(\mathrm{div}\vec{A})_{min} \approx$ (-0.07 addition/dpt - 0.11) dpt/mm, preferably $(\mathrm{div}\vec{A})_{min} \approx$ (-0.05 addition/dpt - 0.08) dpt/mm.

21. Progressive lens as claimed in any one of Claims 13 through 20, whereby the divergence $\mathrm{div}\vec{A}$ of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = -14 mm does not exceed a maximum value of $(\mathrm{div}\vec{A})_{max} \approx$ (0.12 addition/dpt + 0.06) dpt/mm.

22. Progressive lens as claimed in any one of Claims 13 through 21, whereby the divergence $\mathrm{div}\vec{A}$ of the vectorial astigmatism $\vec{A}$ in the horizontal section at y = -14 mm does not drop below a minimum value of $(\mathrm{div}\vec{A})_{min} \approx$ (-0.13 addition/dpt - 0.05) dpt/mm.